

Half Shaft Design Cheat Sheet

Skid torque, torsional stress sizing and 0–60 mph impact

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Axle normal loads	$N_f = m g X_r / L - m a C G_z / L$ $N_r = m g X_f / L + m a C G_z / L$	Longitudinal load transfer. X_f, X_r = CG to axles, L = wheelbase, $C G_z$ = CG height
Skid torque	$T_{\text{skid}} = \mu \cdot N \cdot R_{\text{tire}}$	Max traction-limited torque at a driven wheel before slip. $\mu \approx 0.9$ on dry road
Wheel torque	$T = F \cdot D_{\text{tire}} / 2$	Larger tire diameter raises the torque the shaft must carry
Tractive force	$F = \eta T_e G / R_w$	G = gear $\times$ final drive, $\eta \approx 0.7$ drivetrain efficiency
Solid-shaft shear stress	$\tau = 16 T / (\pi d^3)$	Hollow shaft: $\tau = 16 T d_o / [\pi (d_o^4 - d_i^4)]$
Allowable stress	$\tau \leq \sigma_y / FS$	FS typically 1.5–2.5. Check fatigue separately
0–60 mph time (rough)	$t \approx M_v V / F$	$V = 26.8$ m/s. Ignores drag and rotating inertia; F capped by $\mu M_v g$ on driven wheels

Key takeaways

- A half shaft links the differential or transaxle to one wheel and flexes with suspension travel and steering. It is also called a drive axle or **CV axle**.
- Size it for the **larger** of two torques: skid torque (traction-limited) and powertrain torque (drive-unit-limited), plus abuse loads from traction loss.
- Heavier vehicles and bigger tires both raise required torque, so shaft diameter, joints and the drive unit all scale up.
- For a hollow shaft, mass and rotational inertia trade off: lowering one tends to raise the other. Pick the best balance for launch and handling.
- Failure signs: clicking in turns (outer CV joint), vibration under acceleration, grease slinging from a torn boot, loss of drive to one wheel.
- Axle = whole wheel-to-wheel assembly. Half shaft = one side. CV joint = the flexible joint at each end.